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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF THE SECRETARY

EX PARTE OR LATE FILED

December 6, 1993

By Hand

Mr. William F. Caton
Acting Secretary
Federal Communications Commission
1919 M Street, NW
Washington, DC 20554

Re: Ex Parte Presentation
CC Docket No. 92-297

Dear Mr. Caton:

On behalf of Suite 12 Group ("Suite 12"), petitioner in the above-referenced rulemaking proceeding, enclosed please find two (2) copies of a letter and accompanying studies which were submitted today to the Chairman, the Commissioners, the Commissioners' senior staff, and the relevant LMDS rulemaking staff. The accompanying studies were already made a part of the record in this proceeding in November 1993.

Please place two copies of this submission into the above-referenced docket. Any questions regarding this letter or the attachments should be directed to the undersigned.

Sincerely,

Michael R. Gardner

Michael R. Gardner
Charles R. Milkis
Counsel for Suite 12 Group

Enclosures

No. of Copies rec'd 0+1
List A B C D E

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December 6, 1993

By Hand

The Honorable Reed E. Hundt
Chairman
Federal Communications Commission
1919 M Street, N.W., Room 814
Washington, DC 20554

Dear Chairman Hundt:

Unfortunately, there continues to be considerable confusion and misinformation about the issue of potential interference between Suite 12's proposed provision of LMDS service in the 28 GHz band and the projected future use of the 28 GHz band by various members of the *ad hoc* "coalition" of satellite interests, led by NASA, who are opposing the licensing of LMDS services in the 28 GHz spectrum. As referenced in the enclosures to this letter, Suite 12 Group ("Suite 12"), the petitioner in the LMDS proceeding and the entrepreneurial inventor of the Cellularvision technology, upon which LMDS is based, has addressed these concerns in a complete and technically thorough study, entitled "LMDS Does Not Interfere with NASA ACTS" ("NASA Study"), filed with the Commission on November 24, 1993.

Suite 12's NASA Study clearly demonstrates that when the proper data and correct assumptions are applied to the calculations of potential interference levels, the potential interference level between LMDS and NASA's ACTS system are a relative factor of more than 100 below those estimated by NASA—practically unmeasurable, and far below NASA's acknowledged acceptable interference level. Suite 12's NASA study exposes the numerous, substantial flaws and miscalculations that contributed to NASA's erroneous claim of interference by LMDS.

When these, and other findings in Suite 12's NASA Study are closely reviewed, it is evident that any potential LMDS interference with NASA is minimal at best, well within NASA's acceptable parameters, and simply not a problem. Moreover, Suite 12's NASA Study further confirms that LMDS can easily co-exist with the "coalition" of satellite interests, led by NASA, who have relied upon their own self-serving and flawed analyses in the LMDS rulemaking record to urge the Commission to allow them to essentially "hoard" the 28 GHz spectrum for their potential use in the future. However, the 28 GHz spectrum is crucial to immediate and viable deployment of the pro-consumer, competitive LMDS service and it should be allocated now so that this valuable public resource can generate revenues as Congressionally mandated by the Omnibus Budget Act of 1992.[1]

Specifically, Suite 12's NASA study repudiated the following potential interference problems:

(1) NASA represented in its filings that an appropriate interference to noise ratio, ("Io/No"), for its ACTS satellite receiver would be -10 dB. NASA reported that LMDS yielded an Io/No ranging from -1.7 to -12.5 dB. Suite 12's NASA study reveals that, in rectifying NASA's calculation errors, the potential interference to NASA's ACTS Conus 32 dB antenna is actually -37.9 to -39.9 dB. (See NASA Study, p.10).

(2) NASA's errors in calculating their faulty Io/No levels for this 32 dB antenna resulted from:
- assuming incorrect antenna gains;
- miscalculating pointing angles of most major cities;
- utilizing an inflated earth coverage area;
- misrepresenting LMDS's average cell size;
- substantially increasing the number of LMDS transmitters within the NASA ACTS satellite antenna footprint;
- failing to recognize that LMDS emitters do not use the same polarization, but rather alternate between vertical and horizontal polarizations; and,
- incorrectly assuming that LMDS cells would be uniformly distributed throughout the U.S., since in reality, population density varies by geographical area. (See NASA Study, pgs. 4-9).

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[1] The Commission has acknowledged the viability of Suite 12's technology and LMDS: (1) by granting Suite 12's affiliate, Hye Crest Management, Inc., a waiver license to provide video services in the Brighton Beach area of New York (See Hye Crest Management, Inc., 6 FCC Rcd 332 (1991)); (2) by granting Suite 12 various experimental licenses (See KA2XV6; KA2XLG; KI2XGI); (3) by adopting an NPRM which advocates allocating two 1-GHz blocks per LMDS license in the 28 GHz band (See Rulemaking to Amend Part 1 and Part 21 of the Commission's Rules to Redesignate the 27.5-29.5 GHz Frequency Band and to Establish Rules and Policies for Local Multipoint Distribution Service, 8 FCC Rcd 557 (1993)); and (4) by granting Suite 12 a tentative pioneer's preference license for its LMDS innovations (Id.). For the Commission to now reverse its position on flawed data in the record provided by NASA and by those who seek to prevent LMDS service from being deployed immediately in the largely fallow 28 GHz band would clearly be arbitrary and capricious. and unsound public policy.

(3) The potential interference to ACTS 53 dB antenna high-gain spot beam satellite antenna is -30.4 to -39.9 dB for a representative sampling of major cities—a factor of 100 below NASA's estimates, again virtually immeasurable. (See NASA Study, p.16).

(4) Additional NASA errors in these calculations included miscalculating LMDS antenna gain angles and overestimating NASA satellite coverage area on earth. (See NASA Study, pgs. 11-14).

As to Motorola's claim that LMDS will interfere with the Iridium system, Suite 12 and its consultants have identified numerous significant errors in Motorola's analysis. An accurate and definitive study of the relationship between LMDS and Iridium, which will confirm the absence of interference, will be provided to the Commission shortly.

Along with assurances of adequate compatibility with other potential users in the 28 GHz band, Suite 12 reiterates the necessity for 1-GHz allotments in the 28 GHz band to enable LMDS to become a viable, competitive service. In two studies prepared by Suite 12, "The Need For Wideband Services" ("Wideband Thesis"), and "The CellularVision Modulation Choice" ("Digital Study"), and filed with the Commission on November 22, 1993, Suite 12 definitively addressed numerous questions raised by the Commission's rulemaking staff regarding the bandwidth requirements for LMDS expressed in Suite 12's filings in this proceeding.[2] As Suite 12's filings in the record demonstrate:

(1) a 1-GHz allotment per licensee is absolutely necessary to enable LMDS to become an immediate, widely-available, low-cost alternative to the current cable distribution system by allowing LMDS operators to have the same bandwidth afforded to cable operators via 1-GHz capacity coaxial and fiber optic cable—without adequate, comparable bandwidth, LMDS simply will not be able to fulfill its promise as a competitive alternative.

(2) the allocation of sufficient bandwidth for LMDS will increase the potential value of LMDS for the Federal Treasury if and when an auction scheme is developed for LMDS. However, any attempt to fragment the proposed 1-GHz licenses into smaller allocations will greatly diminish the potential of LMDS, and thus, the value of LMDS licenses, as LMDS operators will be without the equivalent tools with which to compete with incumbent cable and fiber optic operators.

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[2] The Commission's LMDS rulemaking staff, in meetings with Suite 12's principals and counsel on September 28 and October 20, 1993, inquired about the need for a 1-GHz allotment per licensee and the applicability of digital compression technology to the Cellularvision technology for LMDS. Suite 12's subsequent extensive submissions to the formal rulemaking record on November 22 fully address these concerns.

(3) Suite 12's technology utilizes a high-quality FM analog signal, which delivers a superior picture to that of AM-based cable services, with compact disc quality audio. Clearly, future multimedia, widescreen television applications will require high-quality signals.[3]

(4) LMDS is, by nature, a wideband service capable of providing consumers with services beyond entertainment video programming, including public service broadcasting and narrowcasting, education, health care support, small and large business use, and communications with Internet and the "information highway".

Suite 12 urges the Commission to carefully consider the substantially augmented record before it when completing action on the LMDS rulemaking. Based on that record, there is ample evidence to support the Commission's conclusions adopted in the NPRM that the public interest demands the prompt and robust utilization of the 28 GHz spectrum through the allocation of two 1-GHz licenses for the immediate deployment of LMDS services. Only through this action, which the Commission previously articulated and proposed in its adoption of LMDS NPRM, can the consumers throughout the United States immediately gain access to the high-quality, low-cost alternative to cable that Suite 12's LMDS provides.

Thank you for your consideration of these important materials.

Sincerely,

Michael R. Gardner

Michael R. Gardner
Charles R. Milkis
Counsel for Suite 12 Group

MRG:ra

Enclosures
cc FCC Acting Secretary William Caton
(For placement in the LMDS Rulemaking Record)

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[3] As explained more fully in Suite 12's Digital Study, digital compression techniques, at present, provide far inferior picture quality at a significantly greater cost, and simply are not viable for LMDS.

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November 24, 1993

By Hand

Mr. William F. Caton
Acting Secretary
Federal Communications Commission
1919 M Street, NW
Washington, DC 20554

Re: Ex Parte Presentation
CC Docket No. 92-297

Dear Mr. Caton:

On behalf of Suite 12 Group ("Suite 12"), petitioner in the above-referenced rulemaking proceeding, enclosed please find two (2) copies of a technical study prepared by engineer-inventor Bernard B. Bossard demonstrating that the Local Multipoint Distribution Service ("LMDS") does not interfere with the NASA ACTS satellite system ("ACTS"), and that LMDS is sound and economically viable.

In its Comments filed in the above-referenced proceeding, NASA stated that an appropriate interference to noise ratio, Io/No, at its ACTS satellite receiver would be about -10 dB. See Comments of NASA, March 16, 1993, at Appendix B, page 14. NASA's own calculations regarding potential interference to ACTS from LMDS yielded a Io/No ranging from -1.7 to -12.5 dB. Id.

The enclosed study, however, demonstrates that in calculating the potential interference to ACTS from LMDS, NASA made numerous significant errors and improper assumptions which produced severely overstated interference estimates. Accordingly, when these NASA errors are identified and corrected, and the proper calculations are made, the potential interference to ACTS CONUS 32 dB antenna from LMDS actually is -37.9 dB, and possibly as low as -39.9 dB. In addition, the properly calculated potential interference to ACTS 53 dB antenna, for a representative sampling of major cities, ranges from -30.4 dB to -39.6 dB. Importantly, not only are these interference calculations well within NASA's own acceptable parameter of -10 dB, these calculations demonstrate that any potential interference to ACTS from LMDS is virtually unmeasurable.

The study also responds to several inaccurate assertions about LMDS made by NASA in order to reiterate both the technical and economic viability of LMDS.

Please place these two copies of this technical study in the above-referenced docket. Any questions regarding this study should be directed to the undersigned.

Sincerely,

Michael R. Gardner
Charles R. Milkis
Counsel for Suite 12 Group

Enclosures

cc Thomas Tycz, Deputy Chief, Domestic Facilities Division
Robert James, Chief, Domestic Radio Branch
Harry Ng, Senior Engineer, Satellite Radio Branch
Susan E. Magnotti, Esq.

LMDS Does Not Interfere with NASA ACTS

LMDS is Both Practical and Economically Viable

by
Bernard B. Bossard

SUMMARY

This paper addresses the questions raised by NASA regarding the potential interference with the NASA ACTS geosynchronous satellite as well as questions about the viability of the LMDS approach itself.

Specifically, it is shown that the calculations made in the NASA filings in the LMDS proceeding do not, when applied to the physical parameters of the ACTS and LMDS systems, yield nearly as much potential radio interference as was claimed by NASA; and, in fact, the likely interference level is actually a factor of more than 100 below that which NASA itself defines to be acceptable. Such a low potential interference would be virtually unmeasureable.

It is shown that the substantial differences in interference levels calculated by NASA and those used in the LMDS design arise because of incorrect and/or inconsistent application of data and assumptions employed by NASA.

Concerning the viability of the LMDS approach, it also is shown that, contrary to the opinions expressed by NASA:

- cell head ends are economically realizable as a result of polarization isolation which allows for reuse of the spectrum in adjacent cells, and also for point to point repeater interconnects;
- antenna sites are available, even in crowded New York City, through locators, and they are economical due to the low profile of the LMDS equipment;
- LMDS antenna polarization diversity is effective, as demonstrated by measurements;
- fade margins of the system have been verified as adequate by independently conducted measurements; and
- rain does not have as high an attenuation effect on LMDS signals as NASA suggests, because of the fact that signals are not propagated across cell diameters as NASA assumed but rather from cell center to perimeter, as well as the fact that the LMDS design takes into account rainfall data for each cell location in determining cell radius.

INTRODUCTION

This paper is in response to the various submissions of NASA in the Local Multipoint Distribution Service ("LMDS") rulemaking proceeding and, in particular, the NASA submission entitled "Comments of the National Aeronautics and Space Administration" (Reference 1), hereinafter called the "NASA Document", regarding the design and operation of the LMDS. The NASA Document purports that the potential radio interference by LMDS with the NASA ACTS satellite receiver is excessive. In this paper it is shown that when the proper physical data and assumptions are applied to the calculations of potential interference to the NASA ACTS satellite communication system by LMDS, the potential interference levels are a relative factor of more than 100 below those estimated by NASA, and that on an absolute basis they are actually well below the 10 dB signal to interference level recommended as acceptable by NASA itself within the NASA Document.

In addition, in the NASA Document issues are raised by which it is suggested that the LMDS is not practical or economically viable. These issues, too, are addressed in this paper, showing that when the proper radio design calculations are applied to the LMDS the resulting system is both physically efficacious as well as economically viable.

Technical Discussion

From the NASA Document, Table 4.3.1-1 is repeated below for the reader's convenience.

Table I. Figure 4.3.1-1, from the NASA Document) Maximum interference to GEO satellite uplinks from LMDS transmitters

System	Type	Coverage Area in Sq. Mi.	Maximum # LMDS	Aggregate Interfer. (dBW/Hz)	Thermal Noise (dBW/Hz)	Io/No (dB)
ACTS	GEO	121,875	6,094	-200.7	-199.0	-1.7
ACTS	GEO	1,146,241	57,312	-200.9	-199.0	-2.0
ACTS	GEO	1,760,078	88,004	-201.1	-196.6	-4.5
ACTS-LIKE	GEO	3,500,000	175,000	-212.1	-199.6	-12.5
NORSTAR	Feed to GEO	3,500,000	175,000	-200.1	-195.6	-12.5
NORSTAR	User to GEO	2,216,000	110,000	-201.1	-195.6	-5.5

From this Table it can be seen that the NASA calculated interference to noise ratio, Io/No, at the input of its geostationary satellite receiver varies from -1.7 to -12.5 dB depending on the gain of the NASA antenna employed. The NASA Document states on page B-14 and page 21 that an "appropriate criteria would appear to be an Io/No of about -10 dB". Thus it is NASA's recommendation that the interference from LMDS should not exceed 1/10th the noise level of its satellite receiver.

NASA does not include the methods of calculation it used to generate this data. However, within the NASA Document the following basic information is stated:

(1) The ACTS GEO Satellite receiver ("spot") antenna gain is 53 dB (page B-13, table 4.3.1)

(2) The other satellite receiver antenna gain for Conus (whole continental United States) Coverage is 32 dB (page B-13)

(3) The arrival angle from earth to the geosynchronous satellite is a minimum 30° (with respect to the zenith), (page B-13)

(4) The geostationary orbit of the satellite (page B-13) distance is 24,009 miles (paragraph 4.2, Freeman Report, April 11, 1993, Reference 2).

In this paper, we base our correcting calculations on the assumption that items (1) through (4) above are correct. In the NASA Document several of the physical assumptions and approximations are found to be improper and/or inconsistent. The result is that the important interfering signal to noise (Io/No) ratio calculations by NASA are grossly in error, in some cases by a factor of more than 100. Accordingly, NASA's conclusions about the ability of the two systems, the NASA ACTS and the LMDS, to operate without interference are incorrect. That is, while NASA concludes that there would be too much interference, in fact, when the radio calculations are applied in a thorough manner, it is found that there is so little interference (less than 1/100 of the ambient noise level) that it would be virtually unmeasureable.

Specifically, the nature of the errors in the NASA calculations will be discussed in the following categories:

A) LMDS antenna gain in direction of satellite
B) NASA Satellite receiver antenna coverage area on earth
C) LMDS cell area
D) Variation of satellite antenna gain over coverage area
E) Assumption that all LMDS transmitters have the same polarization
F) Assumption of uniform distribution of LMDS cells
G) Atmospheric losses

We now consider each of the above points as they are treated in the NASA Document and how errors in these treatments influence the summary Io/No ratio. The summation of these NASA errors, expressed in decibels (dB) represents the total error, which, as will be shown well exceeds -20 dB, for an error ratio of over 100 to 1.

This error on NASA's part is unduly pessimistic regarding the ability of the two systems to coexist, and leads NASA to the erroneous conclusion that such simultaneous use of the spectrum by both systems is impractical. In fact, application of standard radio system considerations demonstrates that both systems can co-exist.

ERRORS FOR THE ACTS CONUS (32 dB) ANTENNA

We begin the interference evaluation for the case of the ACTS Conus (Continental United States) area coverage antenna. This satellite receiver antenna has a gain of 32 dB. Errors in the NASA Document are evaluated as error ratios for the points A) through F) listed in the INTRODUCTION.

A) **LMDS antenna gain in the direction of the satellite**: NASA assumed the LMDS omni directional transmitter antenna has a 0 dB gain in the direction of the their satellite receiver with a worst case 30° elevation angle (Reference 1, page B-13). Figure A indicates a typical LMDS omni-directional transmitting antenna pattern. In this Figure angles are measured clockwise from the horizontal. Thus, for example, the antenna is pointed skyward (zenith) at an angle of -90°. At the +30° elevation angle (switching to the more easily visualized degrees elevation above the horizon), there is a 25 dB rejection for the LMDS 10 dB gain antenna and a 27 dB rejection for the LMDS 14 dB gain antenna. Thus, the actual LMDS antenna gain at the 30° angle is either -15 dB or -13 dB, not 0 dB as calculated within the NASA Document. This results in a minimum NASA error of -13 dB.

Moreover, the ACTS design parameters indicate that major cities do not have as low a pointing angle as 30°, but rather they are directed even more skyward, further increasing their isolation to terrestrial signals on the horizon such as those of the LMDS. For example, the following elevation angles (ACTS System Antenna Coverage, Appendix 1) apply to selected major cities:

Table II. Angles above the horizon at which the ACTS Geosynchronous satellite must be viewed from various major U.S. cities.

New York	35.9°
Seattle	31.2°
Los Angeles	45.8°
Miami	52.6°

The effect of these higher siting angles makes the isolation afforded by the directivity of the LMDS antenna even greater, to isolation values as high as -30 dB. In our summary, we will take a conservative approach and consider the error as being between -13 to -15 dB. However, the actual NASA error for virtually every American city will be higher than this -13 to -15 dB range.

B) NASA Satellite Receiver Antenna Coverage Area on Earth: The NASA Document utilizes an earth coverage area of 3,500,000 square miles for the 32 dB gain satellite antenna. The actual coverage is 3,000,000 square miles (Appendix 3). The error ratio is 3,500,000/3,000,000 = 1.17. Expressed in decibels, the NASA error is -0.7 dB.

This error in the NASA Document has the effect of assuming that there are too many LMDS transmitters in the beam of the satellite antenna and, accordingly, it contributes to NASA's erroneously high interference signal level.

C) **LMDS Cell Area**: NASA assumed the maximum LMDS cell area to be 20 square miles and used that "smallest cell size, maximum density" for the calculation of the total number of LMDS cells throughout the United States (page B-13, Reference 1). This assumption was made by NASA in spite of the fact that, elsewhere, it acknowledged that the New York cell diameter is 7.8 miles, for an area of 48 square miles, and the Los Angeles cell diameter is 12.4 miles, for an area of 121 square miles (Figure 2-1, page B5, Reference 1). The effect of this computational inaccuracy in the NASA Document also serves to increase the number of LMDS transmitters in a given satellite antenna terrestrial footprint, and with it the amount of interference to be estimated.

In fact, the actual cell diameters in the LMDS system are determined by the anticipated amount and frequency of rainfall in the cell's area. This is because the available transmitter power is fixed and the radius of propagation for the LMDS signal is set by the rain attenuation to be anticipated and the fact that the system is designed to have an availability of 99.9% with a fringe area baseline video signal to noise ratio (S/N) of 54 dB.

Figure C indicates the geographic regions of similarity in rainfall statistics and the following table translates the expected rainfall attenuation for that region in dB per mile. Note that New York City is part of region D-2, in which expected rainfall is more intense. It has a rain attenuation allowance of 4.6 dB per mile in the LMDS design, resulting in an atypically small cell size. The rainfall allowance for various regions in the United States and their accompanying signal attenuation allowances made in the LMDS design are shown in Table III below.

Table III. Expected rainfall in various areas of the United States (see Figure C) and the corresponding LMDS cell areas (based on rainfall attenuation of the signals).

Region	mm/hr	Attenuation/mile	Area sq.mi.
F	5.5	1.5 dB	109
B	6.8	1.8 dB	92
C	7.2	2.0 dB	82
D1	11	3.2 dB	48
D2	15	4.6 dB	30
D3	22	6.7 dB	20
E	35	11.00 dB	9

To be conservative, we used 5.0 dB for the New York area (Region D2) in our rulemaking calculations (page 22 of Petition for Rulemaking, Appendix B, Reference 3). Note that the cell size areas in the United States range up to 109 square miles. In making calculations related to the Conus antenna, which covers most of the United States, we use a geometric weighting of the cell sizes in order to best describe how many LMDS transmitters will be employed. With this approach, the average LMDS cell size for 100% United States coverage at 99.9% availability is estimated to be 52 square miles, and not the 20 square miles NASA assumed. The effect of this correction to the error in the NASA Document calculations is a factor of 52/20 = 2.6. Expressed in decibels, this is a -4.1 dB error.

The miscalculations in (B above), earth coverage area and (C above), LMDS cell size, will result in substantially less LMDS transmitters within the NASA ACTS Satellite's antenna footprint and accordingly less actual interference than estimated in the NASA Document.

Hence, while NASA concludes that the LMDS must have 175,000 cells (3,500,000/ 20), or 175,000 transmitters, the actual number using the same reasoning would be only 57,693 transmitters (3,000,000 square miles/52 square miles). Even this reduced number, less than one third of the quantity of transmitters estimated by NASA, is more than will likely be needed to furnish service to 90% of the population in the United States. Population density is not uniform over the Country, with more than 90% of the population living in less than 40% of the land area. This produces a further correction, which is calculated later (in section F).

D) **Variation of Satellite Antenna Gain Over Coverage Area**: The NASA Document calculations are further pessimistic because there is less gain of the satellite antenna at the edges of coverage. If the antenna has a 3 dB beamwidth over the coverage area, then the signal sensitivity is reduced by 3 dB at the band edges and, on average by 1.5 dB over the coverage area. In this section, calculating the NASA error with regard to Conus antenna coverage, we neglect this factor; however it is taken into account in the spot beam calculations later.

E) **Assumption that all LMDS Transmitters Have the Same Polarization**: NASA incorrectly assumed that all LMDS emitters have the same polarization as the NASA Satellite receiver. Clearly the NASA receiver has a fixed polarization that does not change within its sector of coverage. By contrast the LMDS system alternates between vertical and horizontal polarizations from cell to cell. Accordingly, no matter what polarization the satellite receiver employs (circular polarization, right or left, or linear polarization, vertical or horizontal), the satellite receiver will be, on average, receptive to only one half of all of the signal energy of all of the nationwide distribution of LMDS transmitters. This represents an error in the NASA Document of 50%, or -3 dB.

F) **Assumption of Uniform Distribution of LMDS Cells**: The calculations made in the NASA Document assume that LMDS cells would be distributed uniformly throughout the United States. However, this assumption by NASA overlooks the fact that the population of system subscribers are not so uniformly distributed. Clearly, there is a great difference in the population densities between, for example, New York City, and the large land areas in the Southwest. For conservative planning purposes, a worst-case assumption is that 90% of the population live in 40% of the land area in the country. For example, in the New York MTA, 90% of the population lives in 33% of the area. Accordingly, since most of the country's population is concentrated in less than half of the country's land area, LMDS transmitters will probably occupy only about 40% of the country's total land area. Thus, using an average cell area of 52 square miles, for the 3,000,000 square mile area of the United States (Reference 6), the LMDS area covered would be 1,200,000 square miles. This would require 23,078 LMDS transmitters (using an average cell size of 52 square miles, 1,2000,000/52 = 23,078), which is in sharp contrast to the NASA Document estimate of 175,000 cells. Since the area coverage of LMDS cells was treated separately in earlier sections, we add only the 40% land area correction here. This is a factor of 1.00/0.40 or 2.5. Expressed in decibels, this is a -4.0 dB error.

G) **Atmospheric Losses**: Attenuation in the atomosphere introduces only a factor of -0.6 dB.

Summarizing, the results of A) through G) above, the total miscalculation factor in the NASA Document is as shown in Table IV below.

Table IV. Summary of the NASA error factors as they pertain to LMDS potential interference into the ACTS 32 dB antenna.

		Error Min	Error Max or Probable
A) LMDS Antenna Gain		-13.0 dB	-15.0 dB
B) ACTS Terrestrial Footprint		-0.7 dB	-0.7 dB
C) LMDS Cell Area		-4.1 dB	-4.1 dB
D) ACTS Antenna Gain at Edges		—	—
E) Polarization		-3.0 dB	-3.0 dB
F) Non-uniform LMDS cells		-4.0 dB	-4.0 dB
G) Atmospheric Losses		-0.6 dB	-0.6 dB
	Total	-25.4 dB	-27.4 dB
NASA calculation before correction:	Io/No =	-12.5 dB	-12.5 dB
Corrected NASA calculation	Io/No =	-37.9 dB	-39.9 dB

From this summary, the error introduced into the calculations in the NASA Document through misapplication of the relevant technical values and assumptions appropriate for radio systems is at least a factor of 25.4 dB too high and, possibly, as much as 27.4 dB too high. This means that the estimate of noise introduced into the satellite receiver is overstated by NASA by at least a factor of nearly 350 and, possibly, over 500!

Not only is the relative noise calculation in the NASA Document high by a large factor, the absolute amount of the noise introduced into the receiver is at least 37.9 dB below the ambient noise and, possibly, 39.9 dB. This is at least a full

27.9 dB below that figure which NASA itself recommended as satisfactory in the NASA Document and, possibly, as much as much as 29.9 dB, a factor of nearly 1000 better than NASA predicts. Most importantly, this means that the interfering signal at the satellite's Conus antenna is less than 1/6000th of the background noise! This would be indescernible by any measurement.

ERRORS WITH THE 53 dB ACTS ANTENNA

The factors of error in the NASA Document calculations as they apply to the high gain "spot" satellite antenna are estimated in a similar fashion. However, in this case there is a much larger error apparent in the NASA calculation for the terrestrial coverage area, or "footprint." A proper radio interference calculation in this case must take into account three important variables. These are 1) the LMDS antenna gain in the direction of the satellite, 2) the footprint in square miles of the satellite antenna, and 3) the LMDS cell density in the satellite antenna footprint.

In order to perform these calculations in a manner which neither overstates nor understates the potential interference, we will consider four separate cities in the United States, which are representative of the different cell diameters (related to rainfall) and angles of elevation relative to the geosynchronous satellite. The calculations are performed in a fashion similar to that used for the Conus antenna. It is our understanding, based on our review of NASA filings and conversations with NASA officials, that the 53 dB spot beam antenna covers only one area at a given time.

A) **LMDS antenna gain in direction of satellite**: As noted previously, the NASA calculations treated the LMDS transmitting antenna as having 0 dB gain in the direction of the satellite. For four typical U.S. cities the elevation angles to the satellite are carried forward from Table II to Table V below. Also shown is the net gain of the 10 dB and 14 dB LMDS transmitting antennas at these elevations.

Table V. Elevation angles to the ACTS satellite from major cities and the net antenna gain of the LMDS 10 dB and 14 dB transmitting antennas at those elevation angles.

	New York	Seattle	Los Angeles	Miami
Elevation Angle (deg)	35.9	31.2	45.8	52.6
LMDS Sidelobe 10/14 dB gain Antennas (dB)	-25/-30	-23/-25	-27/-30	-30/-30
LMDS Net Gain at Elevation Angle (dB)	-15/-16	-13/-11	-17/-16	-20/-16
NASA assumed Net Gain (dB)	0	0	0	0
NASA error (dB)	-15/-16	-13/-11	-17/-16	-20/-16

The error in NASA's interference estimate arises because NASA's calculation does not take into account that, particularly in cities with a high elevation angle toward the satellite, the terrestrial based LMDS antenna is looking essentially horizontally and the satellite has a high angle in the sky at which the LMDS antenna sidelobe is low. Consequently, the LMDS antenna radiates much less energy toward the satellite than estimated by NASA using the NASA 0 dB net gain assumption. From the Table it can be seen that this introduces a minimum error of -13 dB, and an error as great as -20 dB, an error factor in the NASA calculation of as much as 100.

B) <u>**NASA Satellite receiver antenna coverage area on earth**</u>: In the NASA Document an earth coverage area of 121,875 square miles for the 53 dB gain satellite antenna (Figure 4.3.1-1, page B-14) was assumed by NASA. This is in error and may represent the inadvertent interchange of some other antenna pattern with the spot beam coverages. However the error occurred, it is substantial.

Consider that a 53 dB gain antenna, of necessity, has a beam width of only 0.32°. (see Appendix 2 for calculation). It should be noted that the NASA Document, itself, indicates a 0.33° beam width, confirming our estimate, and a coverage diameter of 135 miles (page 2, Appendix 1). But this coverage diameter, derived from simple trigonometry, applies for a near 90° elevation angle (tan 0.33° x 24,009 miles = 135 miles). Using this 135 mile diameter results in an area of only 14,314 square mile coverage, not 121,875 square miles as NASA claimed. However, a somewhat larger footprint results because the satellite is in a geosynchronous orbit (in the Equatorial plane) and cities view it at an elevation angle which varies according to their locations, as was shown in the previous section in Table V.

It turns out that the footprint of the satellite antenna is proportional to the cosecant of the elevation angle. Thus, for example, for an elevation angle of 30°, the footprint for a 53 dB gain antenna on earth is 28,415 square miles (see Appendix 2 for calculations), still much less than the NASA 121,875 square mile value. Using the formulas presented in Appendix 2 or the cosecant approximation, the footprint values of the antenna at the elevations of the four representative cities are shown below in Table VI.

Table VI. Footprints of the ACTS 53 dB gain antenna at the elevations of representative U.S. cities and the corresponding NASA interference calculation error factors.

	New York	Seattle	Los Angeles	Miami
Elevation Angle (deg)	35.9	31.2	45.8	52.6
NASA 53 dB gain antenna actual foot-print (sq. miles)	19,930	27,596	17,610	13,147
NASA assumed footprint (sq. miles)	121,875	121,875	121,875	121,875
NASA error (dB)	-7.8	-6.5	-8.4	-9.7

This error in the NASA Document has the effect of assuming that there are too many LMDS transmitters in the beam of the satellite antenna and, accordingly, it calculates an improperly high interference signal level. The lowest error ratio is 121,875/ 27,596 = 4.42. Expressed in decibels, this is an error of -6.5 dB. The error is greater for other cities, up to -9.7 dB.

C) **LMDS cell area**: Continuing in the analysis in the manner used for the Conus antenna calculation, we will take into account the number of LMDS cell transmitters that are in the footprint of the 53 dB gain ACTS satellite antenna in the vicinity of the four selected cities. This is done by combining the footprint data of Table VI with the cell area sizes in Table III and the city locations in Figure C. The results are shown below in Table VII.

Table VII. The rainfall zones and LMDS cell sizes for cities at various elevations.

	New York	Seattle	Los Angeles	Miami
Rainfall zone	D2	C	C	E
Elevation Angle (deg)	35.9	31.2	45.8	52.6
NASA assumed cell area (sq. miles)	20	20	20	20
Actual LMDS cell area (sq. miles)	30	82	82	9
NASA error (dB)	-1.8	-6.1	-6.1	+3.5

Thus, as previously discussed, NASA's treatment of all LMDS cell sizes as having the same area results in an error, ranging from -6.1 dB for Seattle and Los Angeles to +3.5 dB for Miami.

D) **Variation of satellite antenna gain over coverage area**: In the case of the 53 dB gain spot beam antenna, the antenna gain does vary considerably over the coverage area. For example, the antenna gain for Seattle is 49.1 dB, for Los Angeles 49.2 dB, for Miami 50.6 dB, and for New York is assumed to be 51.5 dB. This results in an error of more than -3.0 dB at most coverage edges, and on average an error of about -2.9 dB for the four cities chosen, which further improves the actual Io/No margin.

E) **Assumption that all LMDS transmitters have the same polarization**: The same reasoning applies here as was used for the Conus antenna. The NASA calculation error is -3.0 dB for all cases.

F) **Atmospheric losses**: Again, the same reasoning applies here as for the Conus antenna. The error is -0.6 dB for all cases.

Summarizing the results of sections A) through F) for the 53 dB gain ACTS spot antenna for the four particular cities, the total miscalculation factor of NASA is shown in Table VIII below.

Table VIII. Summary of the NASA document calculation errors for the interference into the ACTS 53 dB gain antenna.

	New York	Seattle	Los Angeles	Miami
A) Error/LMDS ant. gain (dB)	-15/-11	-13/-15	-17/-16	-20/-16
B) NASA footprint error (dB)	-7.8	-6.5	-8.4	-9.7
C) NASA LMDS cell area error (dB)	-1.8	-6.1	-6.1	+3.5
D) Variation of ACTS ant. gain (dB)	-1.5 (est)	-3.9	-3.8	-2.4
F) Polarization error (dB)	-3.0	-3.0	-3.0	-3.0
F) Atmospheric losses (dB)	-0.6	-0.6	-0.6	-0.6
Total Error in NASA Calc. (dB)	-29.7/ -30.7	-33.1/ -31.1	-38.9/ -37.9	-34.4/ -30.4
NASA Calculated Interference Io/No (dB)	-1.7	-1.7	-1.7	-1.7
Interference after error correction (dB)	-31.4	-32.8	-39.6	-30.4